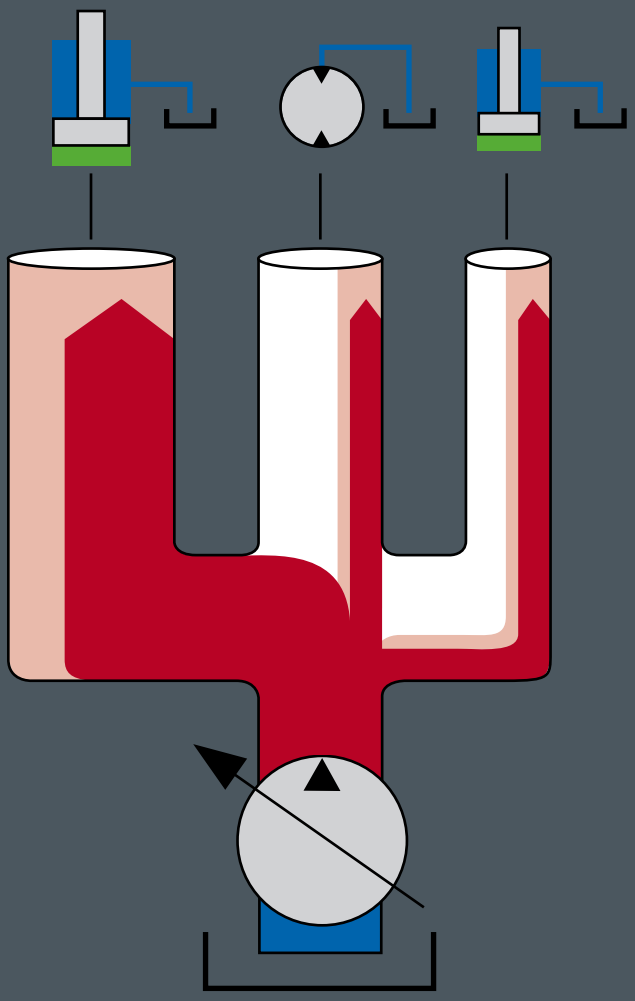
Performance and Flexibility.
LSC. Linde Synchron Control.

Linde Hydraulics

Proportional Flow Distribution.
Linde Synchron Control.

As a trailblazer in Load Sensing Technology Linde looks back on more than 25 years of experience in sophisticated open loop applications. Linde Synchron Control (LSC) has been present in the market since 1984. It is one of the first Load Sensing systems in the market which enables proportional flow distribution by use of downstream compensators.



When operating several actuators at the same time, the available oil is divided according to the requirements of these functions. If all functions actuated together demand a higher flow than can be provided by the pump, the system is saturated. In this case all actuator flows will be reduced evenly. The ratio of their flows to each other remains the same, no actuator will stop unexpectedly. Besides the simplicity of operation, this also has advantages regarding safety.

Besides the valves and the manifold plates of the LSC-system Linde also offers all components required to equip a machine: Pumps, motors, electronic controls and peripheral components. This is enhanced by the Know-How and the decades of experience of the Load Sensing specialist.

— Demanded flow (150% pump capacity)
— Distributed flow (100% pump capacity)

LSC Benefits.
Efficiency and Durability.

Maximum efficiency
On-demand flow control of the regulating pump and elimination of bypass flow losses due to the „closed center" design of the directional control valves prevent wasting energy and fuel. Compared with other systems, LSC enhances fuel economy by up to 10%. Due to high materials handling capability as a result of sophisticated operability and performance, work is completed in the shortest possible time. This saves time and enhances efficiency.

Operational convenience
Sensitive, exactly reproducible control and compensation of loading effects enable intuitive operation of the machine and make readjustments unnecessary. Thanks to proportional flow distribution, the desired performance is always ensured, even under full load.

Maximum performance
Large internal dimensions of the directional control valves, rapidly responding regulating pumps of the series 02 and a system pressure of 420 bar characterize Linde products for open loop applications. They guarantee highest performance even in most demanding applications.

Long service life
Robust technology for the highest quality demands and a reliable design ensure high availability and long service life of LSC system components.

Flexible machine design
The LSC system enables the design of individual machines with distinct differentiation concerning function and reaction.

- >> adjustable starts and characteristics of functions, independently for side A and B
- >> adjustable response and machine reaction
- >> prioritizing of individual actuators
- >> simple addition of functions with the same base components as a result of the parallel system architecture

The new PowerFlow.
Performance and Flexibility.

For 25 years the LSC system has been characterized by excellent performance and high efficiency. With PowerFlow and the innovative modular system the LSC-technology targets future requirements and trends of state-of-the-art machinery. Higher efficiency at lower fuel consumption, more power for the larger machines equipped with LSC and better flexibility for shorter product development cycles.

New valve manifold base plates VT-01

Generously sized internal flow paths supply the new size of directional control valves with minimum losses and also enable further efficiency enhancement with existing valves.
The base plates series VT-01, which were specially developed for the modular design concept with optional electric piloting, serve as basis for modern machines.

VW30. New nominal size of directional control valves

A quantum leap in Load Sensing Technology. With the directional control valve VW30 Linde pushes the flow limits of Load Sensing systems to 600 liters per minute in a globally unique way. For the first time ever the benefits of the LSC-System are now also available for larger scale applications.

Electric piloting

The new base plate enables hydraulic controlling or electric piloting of the directional control valves with all the benefits of an intelligent electronic system control. The robustness of the LSC manifold valve plate remains unchanged. The solenoids are mounted to the valve manifold block in such a way, that they are well protected against environmental influences and mechanical loads. The electric pilot valve bar allows for conversion of hydraulic pilot systems to either partial or full electric operation. In addition, all of the vehicle electrics can be concentrated in a central place.

Modular concept for manifold valve plates

Thanks to uniform interfaces the new base plates can be simply configured to use a variety of directional control valves and intermediate plates for functional modification. Quick availability even for a quantity of 1 enables instant assembly of test vehicles and thus makes the LSC-System attractive for even small production runs. Due to uniform interfaces, machines of different power classes can be equipped with an identical manifold block infrastructure. The manifold valve plate can be extended with accessory modules. This enables simple manufacture of identical basic machines with different equipment versions for various target markets. A high level of identical components for various manifold valve plates helps to manage the variations and saves inventory costs. In case of servicing, individual modules or components can be quickly and simply exchanged.

Actuator 1

>> Pressure level: 300 bar

>> Required flow under partial load: 50 l/min

>> Required flow under full load/saturation: 300 l/min

Actuator 2

>> Pressure level: 200 bar

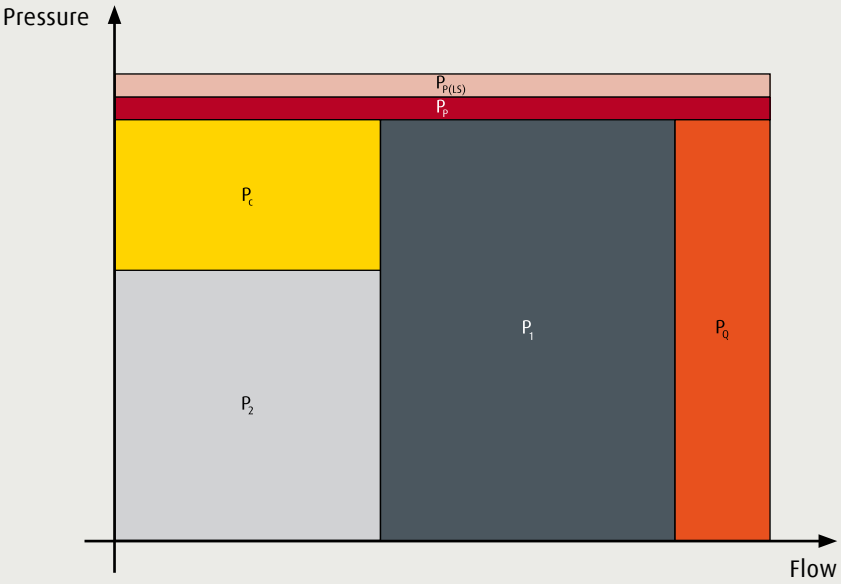
>> Required flow under partial load: 50 l/min

>> Required flow under full load/saturation: 300 l/min

System

>> Power of diesel engine: 120 kW

>> Capacity of pump: max. 400 l/min



System comparison.
NFC, PFC and LSC.

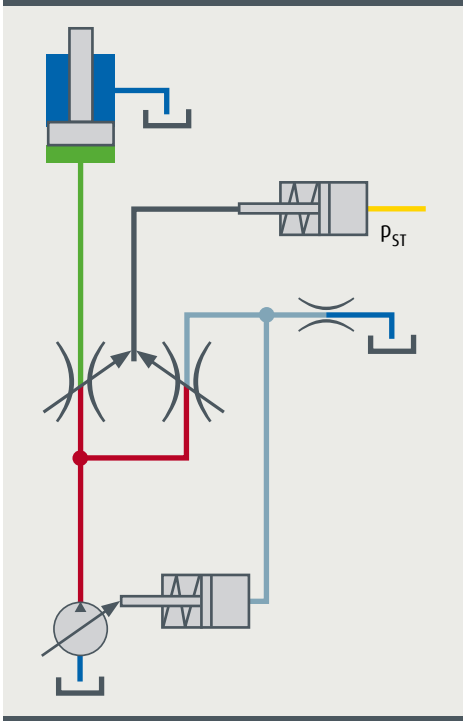
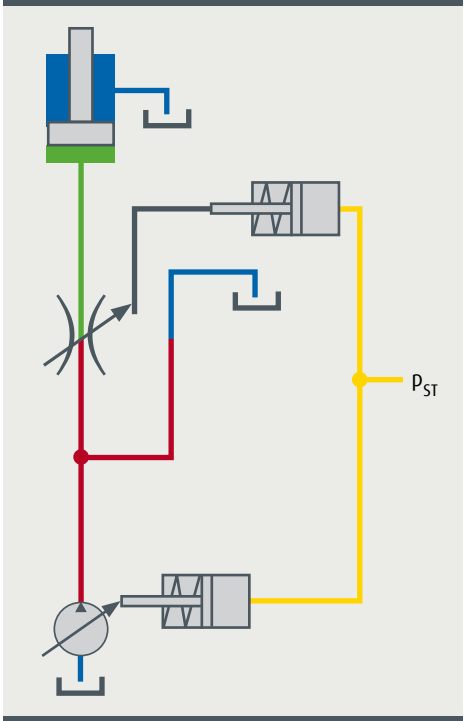
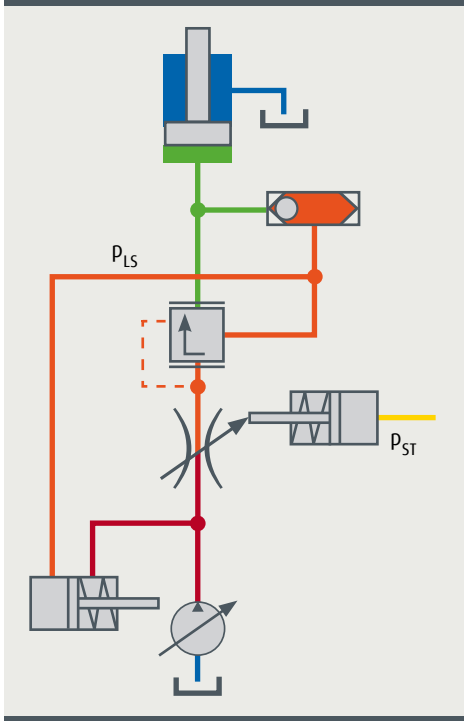
Around the world we find three main, but generally different concepts of open loop hydraulic systems. **Negative Flow Control** (NFC), **Positive Flow Control** (PFC) and **Load Sensing** (LS). In an unbiased comparison the Linde Synchron Control (LSC) has turned out to be clearly the most efficient system.

An example machine with a 120 kW diesel engine, a hydraulic pump with a flow rate of maximum 400 liters per minute and 2 actuators with the values described above, served as basis for this comparison.

The illustration above shows the power ranges of the two actuators and the resulting power losses.

Since both actuators are operated on different pressure levels, so-called compensation losses (P_c) occur in the system, which equalize these differences. The power of the actuators (P_1 and P_2) as well as the resulting compensation losses (P_c) are assumed to be almost identical in all systems. The comparison graphs on page 7 therefore only show the pressure related losses (P_p and $P_{p(LS)}$) and flow related losses (P_Q) of the three systems in comparison.

System comparison.
The architecture.

NFC	PFC	LSC
		
Dynamic pressure in bypass generates pilot signal	Evaluation logic generates pilot signal	Pressure demand generates pilot signal
Self regulating pump	Variable displacement pump	Self regulating pump
Default = Vmax	Default = Vmax	Default = Vmax
„open center“	„open center“	„closed center“
Continuous bypass flow	Continuous bypass flow	No bypass flow
No compensator	No compensator	Secondary compensator

Functionality

The **NFC system** uses a measuring orifice in the bypass oil flow to generate a pressure signal, which influences the swash angle of the regulating pump.

In **PFC systems** the control signal is used to control both valve and pump. A complex evaluation control consisting of valve cascades in combination with software determines a certain swash angle for the pump. The algorithms are exactly matched to the individual machine with a fixed configuration. Operability and efficiency are trimmed for a specific, pre-defined application.

Load Sensing directional control valves are generally equipped with a compensator. The **LSC system** is equipped with a compensator for each actuator side. This compensator determines the pressure currently required at the actuator and feeds a pressure signal* back into the LS line.

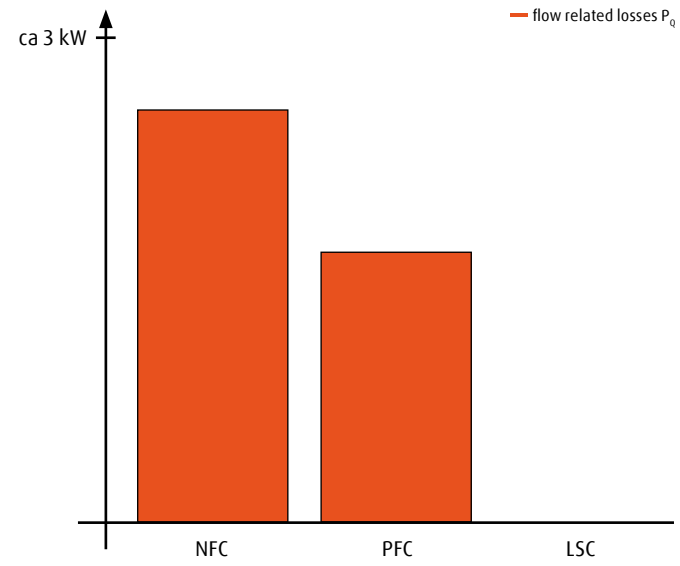
All actuators share this LS line, irrespective of their number. The LS signal is the only signal the pump requires to provide short-term and on-demand flow under high pressure. Additional actuators are connected to the LS line and can thereby be simply integrated into the system. With this it is possible to fit differently equipped machines with a generally identical LSC system.

* The graph on page 5 shows the resulting power as $P_{p(LS)}$.

System comparison.
Power losses under different load conditions.

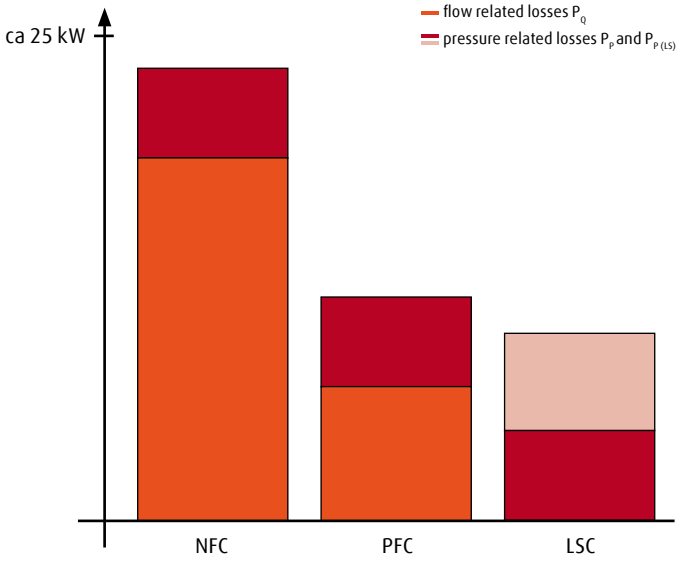
No-load

If no actuator is operated, the directional control valves are in neutral position. NFC and PFC are so-called „open center“ systems. In these systems the pump and tank paths are connected in neutral position. This way the pump permanently delivers an unused flow through the valves back to the tank, in addition to the leakage. In the NFC system up to 50 liters per minute run unused through the machine, in the PFC system up to 30 liters per minute. Due to the corresponding dynamic pressures this results in considerable power losses (P_Q). The directional control valves in the LSC system are designed as „closed center“ valves. Pump and tank paths are not connected in neutral position. Under no-load conditions the pump is regulated back towards zero. It generates a standby pressure of approx. 30 bar. However, since no oil is flowing, the power loss (product of pressure and flow) is zero.



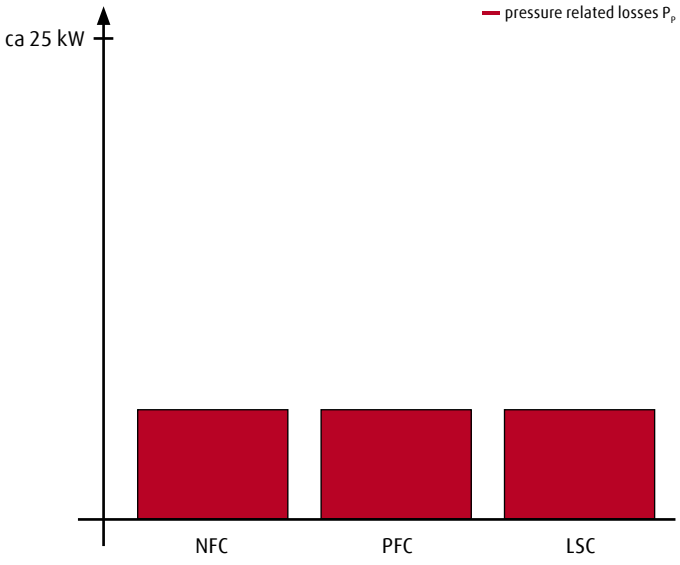
Partial load

If an actuator is to be moved, the operator triggers a control signal. This signal is fed to the spool in the directional control valve. Under partial load one or several actuators are operated. The pump delivers the requested flow and generates the highest demanded pressure. NFC and PFC directional control valves reduce the flow from pump to tank to divert it to the actuators, but still continue feeding oil back into the tank. With the LSC system the pump flow is increased just enough to meet the demands of the corresponding actuators, because the pump does not need to compensate for any bypass flow losses. Even in this situation the pump is always operated under the most favorable conditions.



Full load

If several actuators are operated at the same time and thus require more oil flow than the pump is able to deliver, the system is in saturation. In this condition the NFC and PFC systems no longer deliver any oil back to the tank. Besides the compensation losses, only pressure related losses are relevant. In the LSC system the Δp_{LS} drops because of the flow shortage. The pressure related losses of the three systems under full load are approximately identical.



System comparison.
Movement and operation behavior.

Partial load. Load independent actuator movement without re-adjustment by operator.
If, as in the example, several actuators need to be operated at different pressure levels, the pump needs to provide the pressure demanded by the actuator with the highest pressure requirement. With NFC and PFC systems the operator needs to take this into consideration and actuate or readjust the control elements on the machine as required for the number and pressure levels of the actuators. The LSC valve spool contains a compensator and pressure copier. The highest LS signal is always transmitted to the pump. The compensator in the directional control valve of an actuator on a lower pressure level automatically compensates for the pressure difference. The control signal does not need to be corrected. More load on the actuator generates a higher LS signal. The pump, in turn, provides a higher pressure and thereby compensates for load changes. The control signal is independent from the applied load. The operator never needs to make any readjustments. Apart from this, both compensator and pressure copier determine the load applied to the actuator, even before it is operated. The spool opens the passage between pump and actuator path only after the pressure level of the pump has reached the load pressure level. This ensures that a load will not drop before the start of operation.

Saturation. Consistent Operation thanks to Proportional Flow.
In the example both actuators together would demand 600 liters per minute from the pump which is only able to deliver 400 liters per minute. In NFC and PFC systems certain actuators, which are positioned lower in the control logic or have a pressure level which creates a higher resistance for the available oil flow, will stop while all of the flow goes to the main actuators. This is also the case in Load Sensing systems with upstream compensators.

The operator needs to reduce the flow to some actuators to supply other actuators with oil. Permanent control actions are required and make operation difficult.

In the LSC system the compensators are arranged downstream. For this reason one also refers to it as a „post compensated" Load Sensing system. This enables the so-called „Proportional Flow". The system can be operated as usual, even under saturation. The pump delivers the maximum flow. This flow is distributed to all actuators according to their proportional requirements. A fully operated actuator receives double the amount of oil as a half operated actuator with identical power. In the example both actuators receive 200 liters each. Neither function will stop.

System comparison.
Higher efficiency with LSC.

Duty cycle
The duty cycle of a machine consists of no-load, partial load and full load phases. Statistically the combined movements of individual actuators in the partial load range make up the majority of the cycle time. The efficiency of differently equipped machines of the same power class can be compared by measuring the time and fuel consumption when performing identical duties.

Here the LSC system excels in both aspects. In machines with complex duties and varying applications, measurements confirm a 10% advantage in efficiency over competing systems. Pressure and flow are always made available as required at the optimal point in time. The drive power is utilized efficiently, no energy is wasted. Thanks to the intuitive, load independent operation, machines with the LSC system achieve high productivity.

Owners of machines save twice:
On the one hand they save on fuel, on the other hand in labor costs.

Bottom line. More benefits.

Flexibility in machine design
>> simple, parallel interconnection of actuators with a common LS signal

High productivity
>> compensation of load effects and simultaneous movement of several actuators, even in the case of saturation
>> intuitive operation without readjustment
>> extremely short actuating times of the regulating pump
>> high machine dynamics

Excellent system efficiency
>> low losses
    >> save fuel
    >> enable a smaller cooler design
>> high productivity

1. **Load Sensing directional control valve**
   shown as sub plate mounted valve, alternatively available as sandwich valve
2. **Cross-sections**
   thoroughly dimensioned in several nominal sizes
3. **Valve control spool**
   with integrated compensators and pressure copiers
4. **Compensator**
   downstream, for compensation, 1 per side
5. **Pressure copier**
   integrated in compensator, 1 per side
6. **Centering spring**
   in 2 versions for 2 pilot pressure ranges
7. **Shim**
   independently adjustable start of function on each side
8. **Throttle check valve**
   in pilot pressure port, adjusting valve dynamics
9. **Mechanical stroke limiter**
   independent flow limitation on each side
10. **Pilot-operated pressure relief valves**
    with flat flow-pressure characteristic, make-up function optional

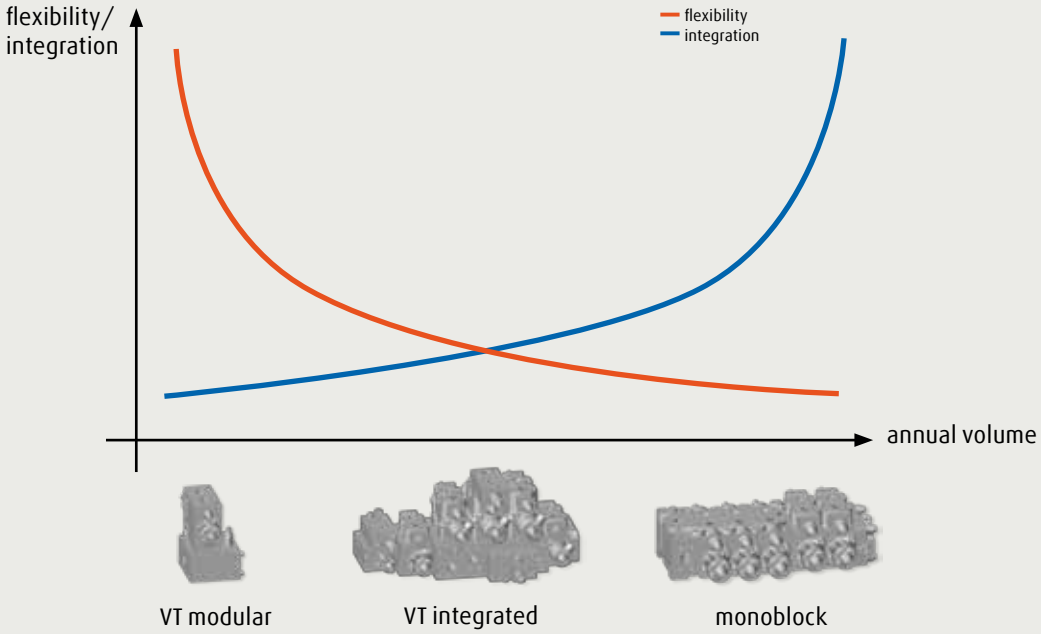
LSC directional control valves.
Basis of individual machine characteristics.

In LSC Technology the directional control valves are the heart of every manifold valve plate. Compared with other Load Sensing directional control valves, the LSC directional control valves are characterized by an integrated control spool design.

The control spool is precision ground to match the directional control valve housing, so that the clearances are quite small. There is very little leakage when the load is held without the actuator being operated. When a function is operated, the compensator will only open after the pump pressure has reached the load pressure level. This prevents lowering of the load at the start of the function, so that no separate load holding valve is required.

The compensators and pressure copiers are directly integrated in the control spool, making sure that the functional components do not need to be positioned at any other place in the valve. This has the advantage that the oil flow only needs to pass through the valve once and not several times. This ensures optimized flow passages in the directional control valve.

The behavior of an actuator can be individually adjusted to the desired characteristic by one compensator and one pressure copier at each side. With this, any physically dependent, different behavior of the actuator - for example when lifting and lowering - can be explicitly adapted.



LSC manifold valve plates.
From modular to highly integrated.

LSC manifold valve plates provide the infrastructure for the directional control valves and other functions of the LSC system. These are available in 3 different designs:

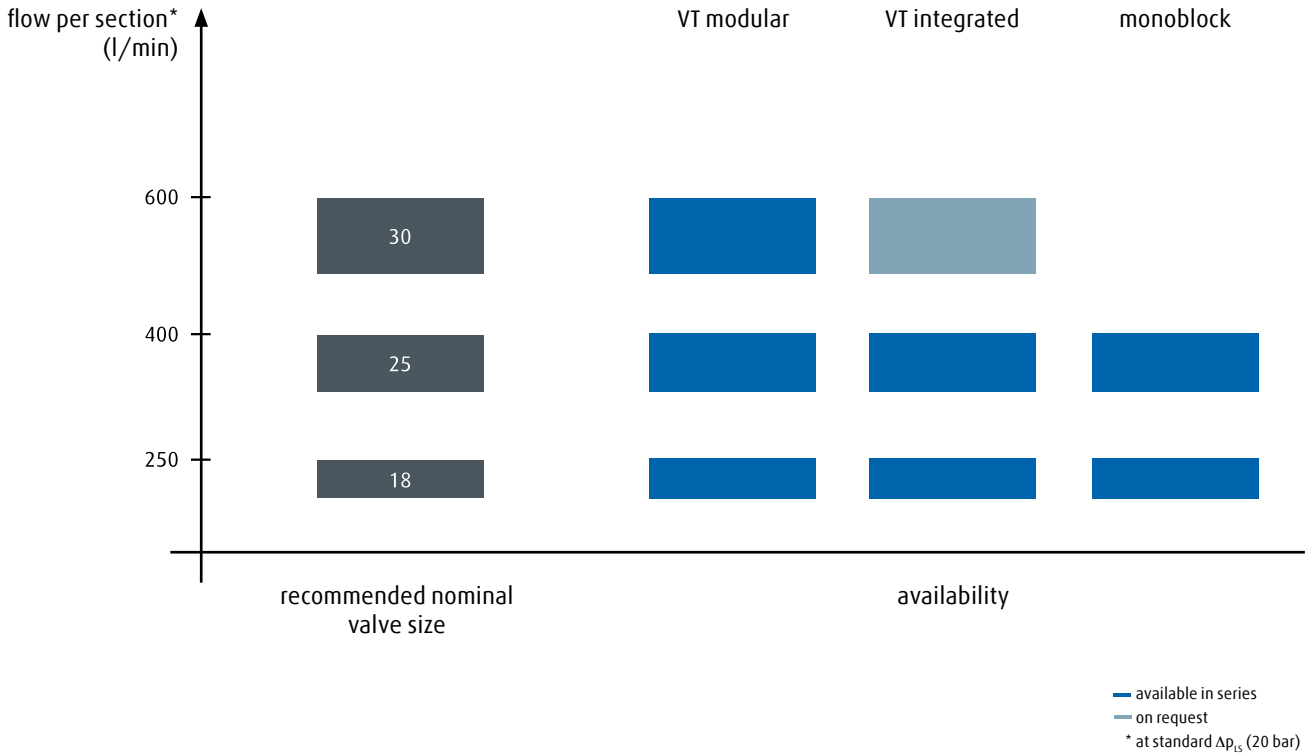
1. VT modular
Modular manifold valve plate based on the building-block design
From a selection of base plates, infrastructure modules, mounting valves, sandwich valves and function modules the mounting valve module is made up for the specific application. For applications from one up to 12 functions, available from a quantity of 1. Ideally suitable for individual applications, prototypes and low to medium volume machines.

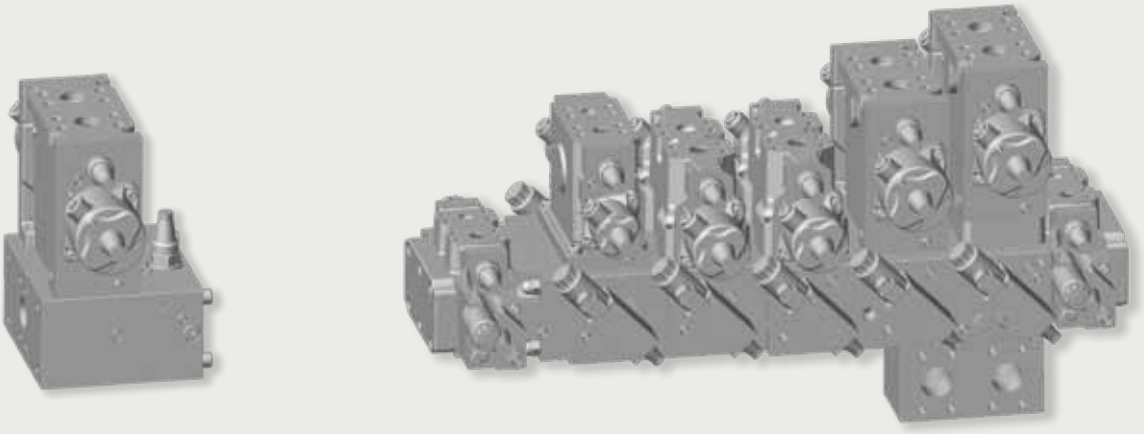
2. VT integrated
Manifold valve plate with integrated additional functions
The base plates have integrated features, such as tank and cooler check-valves or regeneration. The base plates are designed for mounting directional control valves and can be expanded by further sandwich valves, if required. For machines with 3-8 actuators with medium annual production volumes.

3. Highly integrated monoblock
Extremely compact design with directional control valves, basic valve block and functional elements in a common casting. For identical machines with high annual production volumes.

Directional control valves for all requirements.
Selecting the nominal size.

The system efficiency is decisively influenced by the optimum selection of directional control valves. For the various manifold valve plates these are therefore available in different nominal sizes.





VT modular.

More power and more flexibility from a quantity of one.

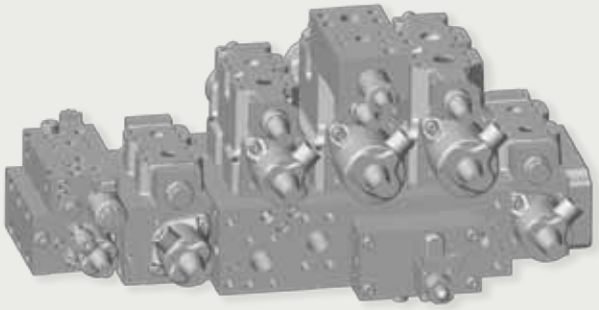
Manifold valve plates of series VT modular are made up of individual components of a modular building block system. This is why manifold valve plates can be configured to optimally match any application with one up to 12 actuators and are readily available from quantities of 1.

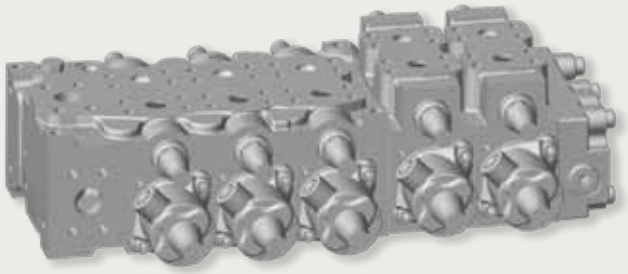
The building block system contains basic valve blocks, infrastructure and function modules as well as directional control valves for mounting in subplate mounted design or in sandwich design to the basic valve block. There are two different valve blocks available for 1-3 or 3-12 functions. Both are available in purely hydraulically or electrically piloted version. Hydraulically piloted basic valve blocks can subsequently be electrified via the pilot valve bar.

Primary functions for the Load Sensing circuit, such as pressure relief, are integrated or can be retrofitted in the form of a function module. Mounted directional control valves supply the main functions of the application and are available in three different nominal sizes. They can be mounted in any position on the basic valve block. Sandwich valves supply the ancillary functions. The valve characteristics can be influenced by intermediate plates and work port-mounted plates.

Advantages

- >> options for hydraulic or electric piloting with identical machine response if desired
- >> flows of up to 600 l/min per actuator
- >> for 1-12 actuators
- >> from quantities of 1
- >> quick availability
- >> low warehouse costs and high serviceability due to the high proportion of identical parts for various manifold valve plate configurations





VT integrated.
Functionality and compactness.

Manifold valve plates of series VT integrated are available in various designs. Functions like pressure relief of the LSC system and a pre-loading function for cooler or tank paths are already integrated in the basic valve block. The different basic valve blocks supply 2 to 8 directional control mounting valves with identical or different cross-sections. Both position and nominal size of the directional control mounting valves are in this case predetermined by their compact design. This provides a compact manifold valve plate for a large number of applications. There are sandwich valves or cover plates for mounted valve ports available to allow different variations of a machine to be equipped with the same manifold valve plate.

Advantages

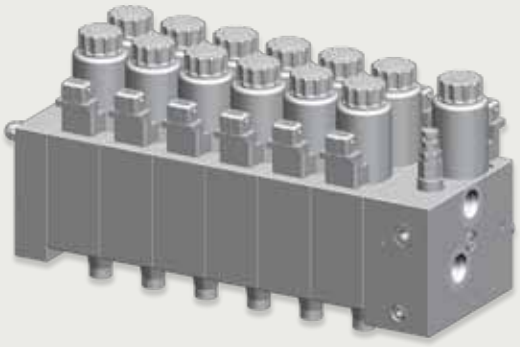
>> compact design for predetermined configuration
>> flows of up to 600 l/min for individual actuators
>> series approved variations for a large number of applications
>> scope of function can be extended using sandwich valves
>> electrifiable via pilot valve bar

Monoblock.
Most compact, specific design.

The monoblock design integrates e.g. three directional control valves and one pressure relief module in a common housing. This results in the most compact package. Specially developed for an application, they are ideal for machines manufactured with identical configuration in high quantities. Despite this fact the monoblock provides a certain degree of flexibility with the option to attach sandwich valves to its front face.

Advantages

>> most compact package
>> customized for a specific application
>> electrifiable via pilot valve bar



LSC peripherals.
Comprehensively designed.

The LSC system offers more than just the valve technology of the manifold valve plates. The optimum function is guaranteed in the interface with Linde HPR regulating pumps series 02, which provide the required oil flow and pressure. The Linde portfolio offers variable displacement, fixed displacement and regulating motors of series 02 to the customer.

The LSC system is supplemented by peripheral electronic components. The electronic pilot valve bar VD7S with proportional solenoids converts electrical signals into hydraulic system pressure. Purely hydraulic systems can subsequently be electrified or the electric piloting can be concentrated in a central location, away from the valve manifold block. This simplifies the use of electronically piloted LSC systems especially in explosion hazard areas.

The periphery is completed by sensors, pedals and joysticks. Powerful, secure and robust electronic controls (LINC) introduce electronic intelligence into the machine. They can be parameterized with the LinDiag® software and enable simple and quick adaptation of the machine.

Our engineers and customer service employees with their decades of experience are always available for you throughout the entire life cycle of the machine. From the design stage through the prototype commissioning, up to the system training and quick response for service issues, Linde Hydraulics is a powerful partner for all open loop applications.

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Turning Power into Motion.